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Ecology of Fishers in the Sub-boreal Forests of North-central British Columbia Year IV (1999-2000): Radiotelemetry Monitoring And Habitat Sampling

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Abstract

We monitored 7 radio-tagged fishers between 1 April 1999 and 31 January 2000 as part of the fourth year of a 5-year project examining the ecology of fishers in sub-boreal landscapes of north-central British Columbia. The broad objectives of the radiotelemetry phase of the study were to document the home ranges, movements, and habitat selectivity of fishers.

From data collected during the first 4 years of the study, we estimated annual home ranges for 6 fishers (1 M, 5 F), 1 winter home range, and 6 non-winter home ranges (1 M, 5 F). We calculated annual and seasonal home ranges from the 95% isopleth of the utilisation distribution using the fixed kernel method. The mean home range size for females was smaller than that of the one male that we monitored for both annual and non-winter home ranges (annual: $\bar{x}_{female}$ = 49.8 km^2, SE = 14.0, n = 5; male = 314.8 km^2: non-winter: $\bar{x}_{female}$ = 54.3 km^2, SE = 25.9, n = 5; male = 228.7 km^2). The home ranges that we observed were larger than that reported elsewhere in North America, likely because of differences in the distribution of resources between our study area and other regions.

We assigned 547 telemetry locations collected during the study to one of six precision categories. We used these precision categories to determine the suitability of each location for habitat analyses at four spatial scales. We have not yet completed habitat selectivity analyses, although we completed habitat assessments at 84 of 113 patch-scale locations of radio-tagged fishers. We identified fishers using 14 different site series in the study area. We amalgamated each site series in the study area into 7 ecosystem types for future habitat analysis.

We located fishers at 35 rest sites during all four seasons and recorded the nearby ambient temperature while these rest sites were occupied. The type of rest site selected by fishers varied with ambient temperature (P = 0.022). Fishers used coarse woody debris (CWD) sites when temperatures were colder than when they used branch or cavity sites. Large pieces of CWD may be important habitat structures for fishers during long periods of extremely cold temperatures because these structures likely provide a more favourable thermal micro-environment than that found at other types of rest sites.

We recorded 6 radio-tagged female fishers using natal and maternal dens during 3 breeding seasons (April-May). We located 8 natal dens of 6 female fishers and documented the movement to 5 maternal dens of 4 of these fishers. We documented re-use of 2 of the natal dens from 1998 during 1999. We recorded female fishers denning exclusively in large diameter, declining black cottonwood or balsam poplar trees. The unique decay characteristics of these large diameter trees likely make them suitable elements for rearing kits.

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TABLE OF CONTENTS

ABSTRACT i

LIST OF TABLES iv

LIST OF FIGURES vi

1.0 INTRODUCTION 1

2.0 STUDY AREA 2

3.0 METHODS 5

3.1 Capture 5
3.2 Immobilisation and Tagging 6
3.3 Radiotelemetry Monitoring 7
3.4 Home Range and Movements 7
3.5 Habitat Use 8
3.6 Habitat Sampling 10
3.7 Reproduction 10

4.0 RESULTS 11

4.1 Captures, Immobilization, and Tagging 11
4.2 Radiotelemetry Monitoring 11
4.3 Mortalities 12
4.4 Home Range and Movements 12
4.5 Habitat Use 16
4.5.1 Landscape Scale 16
4.5.2 Stand Scale 17
4.5.3 Element Scale 17
4.6 Reproduction 21

4.7 Habitat Sampling 22

5.0 DISCUSSION 27

5.1 Capture, Immobilisation, and Tagging 27
5.2 Mortalities 27
5.3 Home Range and Movements 28
5.5 Habitat Use 30
5.5.1 Landscape Scale 30
5.5.2 Stand Scale 30
5.5.3 Element Scale 31
5.5.3.1 Natal and Maternal Dens 31
5.5.3.2 Resting Sites 32
5.6 Reproduction 32
5.6.1 Re-use of Natal Dens 33
5.6.2 Den Attentiveness 33
5.7 Habitat Sampling 34
5.7.1 Future Habitat Sampling 34

6.0 CONCLUSIONS 35

7.0 LITERATURE CITED 36

8.0 APPENDIX 39

LIST OF TABLES

Table 1. Determination of the suitability of locations for habitat analyses at different spatial scales. ▲ denotes scale for which the location is appropriate for habitat analysis 9

Table 2. Independent locations collected for each fisher from 1 April 1999 to 31 January 2000, Williston Fisher Inventory Project. Precision of location refers to the spatial scale at which it can be used for habitat analysis 12

Table 3. Annual home range and core area estimates for radio-tagged fishers during 1996-2000, Williston Fisher Inventory Project. Seven fishers (F08, F11, F12, F13, F14, F15, F30) were not included because of insufficient data ($n < 7$). We did not estimate annual UD home ranges for F03 and F05 because the majority of their locations were collected within the non-winter season only 13

Table 4. Seasonal home ranges and core areas for radio-tagged fishers during 1996-2000, Williston Fisher Inventory Project 15

Table 5. Precision of 547 locations of radio-tagged fishers collected during 1996 - 2000, Williston Fisher Inventory Project 17

Table 6. Element-scale locations of radio-tagged fishers collected from 18 November 1996 to 31 January 2000, Williston Fisher Inventory Project 19

Table 7. Characteristics of natal and maternal dens used by radio-tagged female fishers during 1997, 1998, and 1999 Williston Fisher Inventory Project. F02 used 2 cavities in her 1998 natal den tree as well as 2 different maternal den trees during the same year 20

Table 8. Spatial scales of the locations for which habitat plots were completed and remain for each fisher as of 31 January 2000, Williston Fisher Inventory Project. Fisher patch plots were completed at the actual fisher location, while patch comparison plots were completed at a randomly selected point elsewhere within the same stand 24

Table 9. Proposed grouping of BEC site series into ecosystem types for habitat analysis, Williston Fisher Inventory Project 26

Table 10. Ecosystem types and structural stages of plots completed during summer 1999, Williston Fisher Inventory Project. Bracketted numbers represent stand description plots. $N = 81$ patch comparison, 4 stand description plots 26

Table 11. Estimated number of stand description plots for each stand type (ecosystem type and structural stage) to be completed during summer 2000, Williston Fisher Inventory Project. Cells marked with "*" are stand

types that are expected to be extremely rare or non-existent; therefore, no plots will be scheduled for these stand types. Blank cells indicate sufficient number of samples collected to date 35

LIST OF FIGURES

Figure 1. Location of the study area and biogeoclimatic subzones. The study area is comprised entirely of the SBSmk and SBSwk subzones (hatched area). The solid line is the study area boundary 3

Figure 2. Annual home ranges of radio-tagged fishers during 1996-2000, Williston Fisher Inventory Project. Ranges with solid lines are female home ranges and the range with dashed lines is the male home range (F01). Boundaries of home ranges are 95% isopleths of the UD. All of the fishers except F07 (dead) occupied home ranges during 1999. Approximate scale 1:562,000 14

Figure 3. Leading tree species of stands used by radio-tagged fishers, as recorded on aerial telemetry flights during 1996-98, Williston Fisher Inventory Project. *N* = 249 locations 18

Figure 4. F04 natal den attentiveness during 1999, Williston Fisher Inventory Project. Bars represent the total hours per day away from or in natal den (not timing). F04 used her natal den from 3 April to 1 May 23

Figure 5. Biogeoclimatic ecosystem classification of random plots completed during summer 1999, Williston Fisher Inventory Project. N = 81 patch comparison plots, 4 stand description plots 25

1.0 INTRODUCTION

The fisher *(Martes pennanti)* is a medium-sized member of the Mustelidae (weasel) family that inhabits much of the lowland forested area that dominates the plateau of north-central British Columbia. Although much of this landscape supported viable populations of fishers in the past, fisher harvests have decreased recently. Several factors may have contributed to this decline.

Fishers are considered to be habitat specialists, fulfilling most of their life requirements in forested habitats (Powell 1993, Weir 1995). Evidence from studies of fishers in western coniferous forests indicates that fishers require late-successional seral stages or structural features for foraging, resting, and whelping (Jones 1991, Weir 1995). Because of this association with late-successional forests, forest harvesting activities that focus on late-successional forests can have detrimental effects on fisher populations by altering and degrading the abundance and distribution of the resources that they require.

Aside from the potential effects of forest harvesting, fisher populations are also negatively affected by humans through fur harvesting activities. Fishers are identified as furbearers under the British Columbia Wildlife Act and are trapped for their pelts, despite their populations being considered "vulnerable" (blue-listed) by the provincial Conservation Data Centre. Fishers are also classified by the Wildlife Branch of the Ministry of Environment, Lands and Parks as Class 2 furbearers because they are susceptible to overharvest; their populations occur at low densities and home ranges of individual fishers can span more than one trapline (Banci 1989). Although fisher pelts are valuable relative to other furbearing mammals, the majority of the harvest of fishers in British Columbia is the result of incidental captures in traps set for martens *(Martes americana)*.

The broad goal of this study is to collect information to facilitate management of fishers and their habitat in the industrial landscapes of northern British Columbia. The objectives for the fourth year of this project were to continue to monitor the home ranges, movements, and habitat use of fishers in a representative forest landscape of sub-boreal forests in north-central British Columbia. Specific objectives were to collect additional locations on tagged fishers, identify natal and maternal dens of fishers, identify resting sites, perform habitat assessments at suitable fisher locations, and capture and tag new individuals and those with malfunctioned radiotransmitters.

Funding for this project was provided by Forest Renewal British Columbia (FRBC) and the Peace/Williston Fish and Wildlife Compensation Program, a joint venture between BC Hydro and the British Columbia Ministry of Environment, Lands and Parks. Partners in this inventory program were the Peace/Williston Fish and Wildlife Compensation Program, the BC Ministry of Environment, Lands and Parks, Slocan Group Mackenzie Operations, Donohue Forest Industries Inc., and the British Columbia Trapper's Association. The project was conducted co-operatively with the FRBC-funded Northern Wolverine Study, whose personnel assisted in the collection of capture data. F. Corbould administered project funds, assisted in the field, and provided reviews of drafts of this document. A. Bowser, G. Carlson, A. Hahn, and J. McCormick helped monitor traps, radio-tag fishers, perform radiotelemetry, measure habitat, and enter data. M. McAdie, DVM performed the surgery to tag fishers with intraperitoneal transmitters. Members of the Peace/Williston Fish and Wildlife Compensation Program Technical Committee provided helpful comments on earlier drafts of this report.

2.0 STUDY AREA

The study area covers approximately 2,160 km^2 and is centred 70 km north-west of Mackenzie, British Columbia (Fig. 1). The entire area is within the Peace River drainage. All watersheds within the study area drain into the Williston Reservoir. The major watersheds in which the study is occurring are the Manson, Omineca, and Mesilinka Rivers. The study area is bounded by Williston Reservoir to the east, Nation River to the south, the Wolverine and Swannell Ranges to the west, and the bend in the Mesilinka River (south of Carina Lake) and Mica Creek to the north.

The study area is located entirely within the Mackenzie Forest District of the Prince George Forest Region and lies within the Sub-Boreal Interior ecoprovince, Omineca Mountains ecoregion, and Parsnip Trench, Southern Omineca Mountains, and Manson Plateau ecosections (Demarchi 1995). The boundary of the study area is defined by the extent of the Sub-Boreal Spruce (SBS) biogeoclimatic zone that occurs in this region. The topography of the study area is characterised by a gently rolling plateau rising from the Rocky Mountain Trench (Williston Reservoir) in the east to the slopes of the Wolverine and Swannell Ranges in the west. The plateau is drained by a series of small creeks with poorly developed or non-existent floodplains. Floodplains with extensive riparian zones exist on only three major rivers: the Manson, Omineca, and Mesilinka Rivers.

Figure 1. Location of the study area and biogeoclimatic subzones. The study area is comprised entirely of the SBSmk and SBSwk subzones (hatched area). The solid line is the study area boundary.

The study area is comprised of two subzones of the SBS. At elevations below 800 m, the moist cool subzone (SBSmk) of the SBS occurs, while between 800 and 1100 m, the wet cool subzone (SBSwk) occurs (MacKinnon *et al.* 1990). The SBSmk comprises the majority of the study area, covering approximately 70% of the area. Annual precipitation in the SBSmk is 690 mm and 905 mm in the SBSwk (MacKinnon *et al.* 1990). Snowfall in the SBSmk is 335 cm/year and 1075 cm/year in the SBSwk (MacKinnon *et al.* 1990). Snow cover in the study area generally lasts from November until April.

Forests in the SBSmk are dominated by hybrid spruce *(Picea glauca* x *engelmannii),* lodgepole pine *(Pinus contorta),* black spruce *(Picea mariana),* and subalpine fir *(Abies lasiocarpa),* with deciduous components of trembling aspen *(Populus tremuloides)* and paper birch *(Betula papyrifera).* Black cottonwoods *(Populus balsamifera* spp. *trichocarpa)* occur as a minor element in riparian-type ecosystems and occasionally in other areas with sub-hygric or wetter ecological moisture regimes. The composition of forests in the SBSwk is similar, with hybrid spruce and subalpine fir being more dominant.

Disturbances in the SBSmk and SBSwk follow a typical pattern. The principal natural disturbance factors in these ecosystems are fire and insect outbreaks (MacKinnon *et al.* 1990). Young forest stages are comprised primarily of lodgepole pine, while later successional stands are dominated by spruce and subalpine fir. The SBSmk has a natural disturbance regime of frequent, large-scale burns (up to 100,000 ha) occurring about every 125 years, while the ecosystems in the SBSwk portion of the study area are exposed to moderate-sized burns (20 to 1,000 ha) with a fire cycle of about 200 years (British Columbia Ministry of Forests and British Columbia Ministry of Environment, Lands and Parks 1995).

Human-caused disturbance in the study area is extensive. With the flooding of the Williston Reservoir in 1968-72, many of the valley bottom riparian forests in the area were submerged, mostly in the lower Omineca, Manson, and Parsnip Rivers. Forest harvesting, primarily of mature and late-successional stands, has occurred throughout the study area over the past 25 years. Forest harvesting and natural disturbances have resulted in a mosaic of seral stages and stand types throughout the study area.

The study area encompasses five registered fur harvesting traplines. Traplines in the northern portion of the study area include 738T009, which is located primarily on the Mesilinka River, and 738T010, which occupies the Chunamon Creek/Raspberry Harbour area. Trapline 729T005 runs from km 155 on the Finlay Forest Service Road south

beyond the Manson River. Trapline 728T007 occurs on the Manson River drainage west of the Carmella Creek and 729T004 occupies the Blackwater Creek area.

3.0 METHODS

3.1 Capture

We attempted to capture fishers to radio-tag new animals and replace malfunctioned and expiring transmitters on previously tagged individuals. We used three types of live-trap sets to capture fishers: log-cabin (Krebs 1993), Havahart collapsible, and Havahart permanent. We placed the Havahart traps on beds of hybrid spruce or subalpine fir boughs and covered the top, sides, and bottom of the traps with disassembled waterproof cardboard boxes (tree planting boxes). Traps were lined with straw and covered with more boughs so that snow or wind did not penetrate the trap. We also added straw to all traps to provide bedding material. We usually baited each Havahart trap with approximately 500 g of moose meat, but occasionally used grouse and duck carcasses for bait. Log-cabin traps were baited with pieces of moose carcass (1.5 - 3 kg).

We took several actions to enhance the efficacy of the traps. Vegetation near each trap site was scented with a combination of commercial fisher, marten, and beaver lure, and skunk oil. Scent was re-applied every 3-5 days. Prior to setting the trap for the first time, the pan, cable, and door of each trap were lubricated with petroleum jelly and tested to ensure that the trap functioned properly.

We checked traps daily and assessed the functioning of each trap every 2-3 days. We considered trap nights during which the trap malfunctioned (i.e., blocked, tripped, escape, or no bait) as partial trap nights (0.5 trap night). When we captured non-target species in the traps, we fed them a small amount of strawberry jam (to reduce likelihood of hypoglycaemia) and released them immediately. We closed and removed traps at locations where martens were captured on more than 5 consecutive nights.

We recorded temperatures and snow depths at various locations throughout the study area. We used remote temperature data loggers (Optic Stowaway®) to record hourly temperatures at all climate stations. We also used a remote snow monitoring station comprised of a sonic ranging sensor, temperature probe, and data logger to record snow depth every 2 hours. Climate stations were placed under normal forest canopy at least 10m from the forest edge. We calculated mean

daily temperatures and mean snow depths using data collected from each of these stations.

3.2 Immobilisation and Tagging

Prior to immobilisation, we estimated the body weight of each fisher to ensure that animals were administered appropriate dosages of anaesthetic. We used a handling cone to restrain the animal and administered drugs with a hand-held syringe for fishers captured in Havahart traps. We injected anaesthetic to fishers in log-cabin traps using a jab-stick.

Fishers were immobilised using a 1:1 mixture of tiletamine hydrochloride:zolazepam hydrochloride (Telazol®). We attempted to administer Telazol® at 5 mg/kg to induce anaesthesia for further anaesthetizing during the implant surgery. Because of the dramatic decreases in body temperature that we observed during immobilisations in the previous years of our study (Weir 1999), we placed the immobilised fishers in a sternal position over warm hot-water bottles.

We measured and monitored fishers while they were immobilised. Sex, body weight, and cranial and skeletal measurements were documented. We also collected hair samples from each fisher. We classed most fishers as adults or juvenile by palpating the saggital crest and examining the level of tooth wear (Powell 1993). We removed a premolar 1 tooth for cementum annuli analysis (Strickland *et al.* 1982) from healthy fishers that were difficult to age using this technique. Photographs were taken of the head, dorsal, and ventral regions. Respiration and cardiac rate, body temperature, and capillary refill time were also recorded at regular intervals while the fishers were immobilised.

Each fisher was surgically fitted with an intraperitoneal (IP) transmitter (Telonics® IMP/300/L). To maintain anaesthesia for the implant surgery, a mask was placed over the animal's face and a mixture of isoflurane (Aerrane®) and oxygen was administered, delivered by a portable vaporiser. The concentration of isoflurane was initially 3% for induction and 1-2% for maintenance of anaesthesia.

A routine surgical preparation of the ventral midline was performed following hair removal, which was limited to an approximately 3 cm by 5 cm area to minimise heat loss after release. A skin incision was made caudal to the umbilicus. Subcutaneous tissue was bluntly dissected and the incision continued through the linea alba. The implant was then inserted into the abdominal cavity and tucked around the body wall,

adjacent to the right kidney, dorsal to the intestines. The abdomen was closed with 3-0 absorbable suture materials. The incision was sealed with skin glue (Vetbond®).

Following the surgery, we wrapped each fisher in a blanket and placed them back in the live trap to recover from anaesthesia and to reduce the likelihood of hypothermia. We released the fishers from livetraps when they were fully recovered from the effects of the anaesthetic.

3.3 Radiotelemetry Monitoring

We located fishers using standard ground and aerial telemetry procedures (Resources Inventory Committee 1998a). From the ground, we recorded directional bearings from permanent ground stations to fishers using a three-element, collapsible Yagi antenna. We estimated locations and 95% error polygons from ground telemetry using Locate II software (Nams 1991). We estimated the precision of each location using the 95% error polygons for ground locations. We then classified each location into one of six precision categories: ± <1 m, ± 1-30 m, ± 31-50 m, ± 51-100 m, ± 101-250 m, and + 250-500 m. We assigned capture locations to the least precise category (250-500 m) because of the potential bias of these data.

We located fishers whenever possible from the ground. All ground telemetry work used UTM coordinates from 1:20,000 forest cover maps or 1:20,000 orthophotographs. All locations were recorded using North American Datum 1983.

We classified each location into one of two seasons for home range and habitat use analysis. We defined the seasons as winter (15 November to 31 March) and non-winter (including rearing; 1 April to 14 November). We considered locations to be sufficiently independent for home range and habitat use analyses if they were separated by at least 16 hours. We did not consider repeated locations at traps, rest sites, or natal dens within a season or year to be sufficiently independent for home range and habitat use analyses.

3.4 Home Range and Movements

We estimated the size and location of the home range of each resident fisher using two estimators. For fishers with 30 or more locations, we estimated home ranges using the 95% isopleth of the utilisation distribution (UD) generated from the fixed kernel method with the smoothing parameter selected by least-squares cross-validation (Worton 1989, Seaman *et al.* 1999). We calculated the core area of each home range using the 50% isopleth of the same distribution. To allow

comparison with other studies, we also calculated home ranges using the 95% minimum convex polygon (MCP; Mohr 1947) method for fishers with 20 or more locations. For fishers with fewer than 20 locations, we used the 100% MCP method to calculate the total area over which we recorded locations. We excluded multiple observations of fishers at the same location (e.g., trap sites, dens, rest sites) from home range calculations because inclusion of these data resulted in skewed estimates of the UD. We used The Home Ranger software (Hovey 1999) for kernel home range calculations and CALHOME (Kie *et al.* 1994) software for MCP calculations.

We calculated annual and seasonal home ranges for each fisher for which we had sufficient data. We pooled locations across years for each fisher for the calculation of their annual home range. We estimated seasonal home ranges from data collected within one season (across multiple years) for each fisher.

3.5 Habitat Use

There are four spatial scales at which habitat use patterns may be analysed. These scales are nested and range from fine scale (element) to coarse scale (landscape). *Elements* are single structural features of habitat such as a piece of coarse woody debris or a large tree. *Patches* consist of assemblages of habitat elements and range in area up to 0.3 hectares. *Stands* are composed of patches and vary from 1.5 ha to hundreds of hectares. The *landscape* is composed of stands and is defined as the boundary of our study area (i.e., Sub-Boreal Spruce biogeoclimatic zone).

Depending on its level of precision, we considered each location for its suitability for inclusion in habitat analyses at these 4 spatial scales (Table 1). Precise locations are suitable for inclusion in analyses at fine spatial scales (e.g., element scale), while less precise locations are only suitable for coarser-scale analyses (e.g., landscape scale). For example, the location of a fisher at a resting site could be used as data for habitat analysis at all four spatial scales. Because we know which element the animal was using, we also know which patch it was using, along with which stand and point in the landscape. However, with less precise locations, such as a ground telemetry location with an error polygon of 1.5 ha, we could only reliably identify which stand and point in the landscape was used by the fisher. Thus, more precise locations are appropriate for habitat analyses at the finest scale up to the coarsest scale, while imprecise locations preclude use for analyses at all but the coarsest scales.

Table 1. Determination of the suitability of locations for habitat analyses at different spatial scales. ▲ denotes scale for which the location is appropriate for habitat analysis.

Precision of location	Error area	Spatial scale			
		Element	Patch	Stand	Landscape
±<1 m	none	▲	▲	▲	▲
± 1-30 m	< 0.3 ha		▲	▲	▲
± 31-50 m	0.3-0.8 ha			▲	▲
± 51-100 m	0.8-3.0 ha			▲	▲
± 101-250 m	3.0-19.6 ha				▲
± 251-500 m	19.7-75 ha				▲

During aerial telemetry flights, we classified the stand used by radio-tagged fishers based upon the dominant species of the overstory. Each stand was classified into one of the following categories: black cottonwood, trembling aspen, other deciduous trees (paper birch, willow *[Salix* spp.], or alder *[Alnus* spp.]), hybrid spruce, black spruce, lodgepole pine, subalpine fir, regenerating clearcuts (usually a mix of planted and naturally regenerating species) or burns (5 - 30 years old), and open or otherwise recently disturbed areas.

Whenever possible during ground telemetry monitoring, we collected specific information about the elements used by fishers. We classified the use of each element into three categories: natal and maternal dens, resting sites, and active locations. Natal dens were those structures used by female fishers for whelping. Maternal dens were those structures used in weeks following abandonment of the natal den by the female and kits (i.e., second rearing den). Resting sites were elements that were used for temporary resting by female fishers following abandonment of natal or maternal dens and male fishers through all seasons.

We identified the elements used by moving fishers during winter by homing in on a radiotransmitter, locating the fisher's tracks, and backtracking 50 m. At this point, we noted the element that the fisher was walking upon (if any) and flagged the site so that we could return during snow-free periods to measure the attribute.

We grouped resting sites into 4 categories: in tree cavities, on rust brooms or tree branches, under pieces of large coarse woody debris (CWD), and in burrows or rock crevices. We measured the ambient temperature at nearby sites while radio-tagged fishers used each of these categories of resting sites. We examined the effect of temperature on the type of rest sites selected by fishers using a nested ANOVA

design with the acceptable probability of committing a type I error set at 0.05.

3.6 Habitat Sampling

We used habitat assessment plots to examine habitats that were 1) used by fishers, and 2) available within the study area. At every habitat plot, we gathered information at the stand and patch spatial scales. For those locations of fishers where we identified either tracks or the element being used by the fisher, we also gathered information at the element spatial scale.

We used procedures outlined in the Resources Inventory Committee (RIC) standards for terrestrial ecosystem mapping and vegetation inventory sampling to assess habitat. We completed site descriptions and collected soil and vegetation data following terrestrial ecosystem mapping standards for ground inspection plots (RIC 1998b). We collected coarse woody debris (CWD) and tree mensuration data following vegetation inventory sampling procedures (RIC 1999). The amount of data that we collected varied depending on the purpose of the plot.

We measured habitat characteristics using 3 slightly different types of assessment plots to allow us to describe fisher habitat and compare it to the habitat that was available. *Fisher patch plots* (FPP) were completed at patch-scale locations (i.e., locations with error polygon < 0.3 ha) that we collected since November 1996. Data collected at these plots were limited to patch-scale structural variables (tree mensuration, volume of CWD, vegetation strata). *Patch comparison plots* (FCP) consisted of similar measurements, completed at a random location within the same stand as the fisher patch plot. In complex polygons (i.e., those with more than one stand type), the patch comparison plot was randomly placed in the same stand type that occurred within that polygon. FCP values are considered representative (normal) for the stand. Data from the FCP were then compared to the FPP to examine patch-scale selectivity. *Stand description plots* (SDP) were completed at randomly located points in stand types within the study area for which we did not collect any patch-scale telemetry locations. In addition to PCP's, SDP's were used to quantitatively characterize each type of stand.

3.7 Reproduction

We attempted to locate and monitor female fishers that gave birth to kits during the rearing season (April - June). We considered females to have whelped when we repeatedly located them using the same structural element over several weeks *(sensu* Paragi 1990, Powell *et al.*

1997). Upon identification of natal dens, we set up continuously-monitoring radiotelemetry data loggers (Lotek SRX_400 with W/16 option) to determine the times that the female was at her den. The data logger was set to record the presence or absence of a signal from the female's radiotransmitter within a radius of less than 50 m at 15-minute intervals.

4.0 RESULTS

The data included in this report varies by section. Data reported in sections *4.1 Captures, Immobilization, and Tagging, 4.2 Radiotelemetry Monitoring, 4.3 Mortalities, 4.6 Habitat Sampling* and *4.7 Reproduction* are limited to that collected between 1 April 1999 and 31 January 2000 (year 4). Sections *4.4 Home Range and Movements* and *4.5 Habitat Use* include all data collected since 18 November 1996.

4.1 Captures, Immobilization, and Tagging

We monitored 83 trap sites for 1,179 trapnights from 8 to 28 November 1999, during which we captured 3 fishers (0.25 captures/100 trapnights). All of the captures were of previously tagged fishers: F01 (Beau), F02 (Patches), and F20 (Fin). Each fisher that we caught was tagged with a new intraperitoneal transmitter and released at the capture site.

Neither of the 2 fishers that had their IP transmitters replaced (F02, F20) appeared to have suffered any complications from the transmitter or the prior surgery and the old transmitter was removed easily. The wounds caused by F01's radiocollar that we observed in November 1998 (see Weir 1999) had completely healed, with no hair loss or scarring evident. F01 was in extremely good physical shape; his body weight had increased by 1.5 kg since his radiocollar was removed.

4.2 Radiotelemetry Monitoring

We collected 107 locations for 6 radio-tagged fishers between 1 April 1999 and 31 January 2000, of which 82 were sufficiently precise and independent to be used in home range and habitat use analyses (Table 2). All of these locations were collected using ground telemetry. We located fishers 64 times during the non-winter period and 18 times during the winter season.

Table 2. Independent locations collected for each fisher from 1 April 1999 to 31 January 2000, Williston Fisher Inventory Project. Precision of location refers to the spatial scale at which it can be used for habitat analysis.

	Precision of location			
Fisher ID	Element	Patch	Stand	Landscape
F02	2	4	9	12
F04	5	7	11	18
F09	1	2	3	9
F17	5	7	12	21
F18	5	5	10	19
F20			1	3
Total	18	25	46	82

4.3 Mortalities

None of the 7 radio-tagged fishers died between 1 April 1999 and 31 January 2000. However, a post-mortem of F07 (Inka), who died during January 1999, revealed that a lynx *(Lynx canadensis)* killed her.

4.4 Home Range and Movements

We estimated the annual and seasonal home ranges of several fishers from data collected between 18 November 1996 and 31 January 2000. We estimated annual home ranges for 6 radio-tagged fishers (5 females, 1 male; Table 3, Fig. 2). The mean annual 95% UD home range for females was smaller than for the male ($\bar{x}_{female}$ = 49.8 km^2, SE = 14.0, n = 5, male = 314.8 km^2). The mean core area of the females was also smaller than that of the male ($\bar{x}_{female}$ = 11.8 km^2, SE = 4.0, n = 5, male = 73.2 km^2).

We collected sufficient data to estimate non-winter seasonal home ranges for 5 fishers and winter seasonal home range for 1 fisher (Table 4). As with the annual home ranges, the home range of the male fisher was much larger than those of the females during the non-winter season (male = 228.7 km^2, $\bar{x}_{female}$ = 54.3 km^2, SE = 25.9, n = 5). The home range size decreased from winter to non-winter for the one female (F02) for which we could perform this calculation (winter = 52 km^2, non-winter = 17.8 km^2). The home ranges during the non-winter season of females with kits ($\bar{x}$ = 46.0 km^2, SE = 31.7, n =4) were smaller when compared to the one female without kits (87.5 km^2). Reproducing females who had non-winter home ranges that included extensive floodplain ecosystems (F02, F03, F07) had smaller home

Table 3. Annual home range and core area estimates for radio-tagged fishers during 1996-2000, Williston Fisher Inventory Project. Seven fishers (F08, F11, F12, F13, F14, F15, F30) were not included because of insufficient data (n < 7). We did not estimate annual UD home ranges for F03 and F05 because the majority of their locations were collected within the non-winter season only.

			Home range (km^2)		Core area[d]
Fisher ID	Sex	n[a]	MCP[b]	95% UD[c]	(km^2)
F01	M	61	153.8	314.8	73.2
F02	F	101	74.8	31.9	6.1
F03	F	39	24.8		
F04	F	53	42.9	27.7	5.0
F05	F	38	42.1		
F06	M	15[e]	45.6		
F07	F	51	29.3	23.1	5.3
F09	F	71	60.8	93.9	23.8
F10	F	8[f]	1237.0		
F16	F	7	10.2		
F17	F	35	26.4	72.0	18.9
F18	F	22	19.0		
F20	M	20	123.0		
F300	F	7	15.6		

a Includes all capture, mortality, aerial telemetry, and ground telemetry locations, except for multiple observations at the same location

b Minimum convex polygon method (95% MCP for animals with ≥ 20 locations, 100% MCP for < 20 locations)

c Utilisation distribution estimated from fixed kernel method

d 50% utilisation distribution

e Locations following home range establishment

f Locations while dispersing

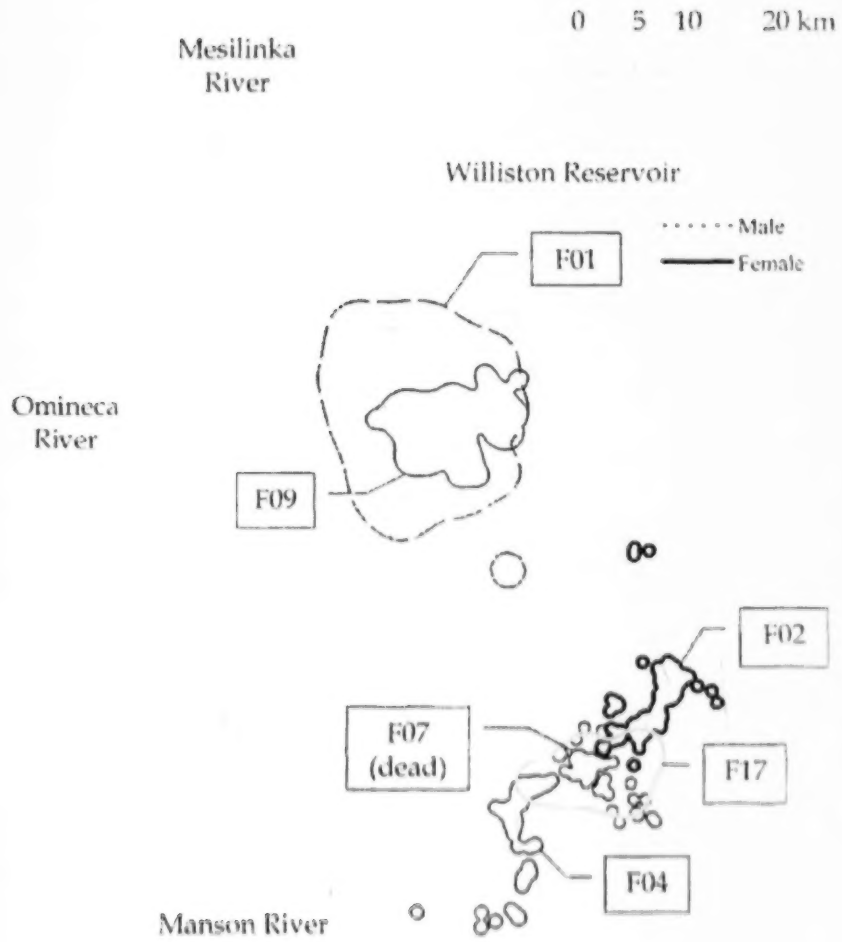

Figure 2. Annual home ranges of radio-tagged fishers during 1996-2000, Williston Fisher Inventory Project. Ranges with solid lines are female home ranges and the range with dashed lines is the male home range (F01). Boundaries of home ranges are 95% isopleths of the UD. All of the fishers except F07 (dead) occupied home ranges during 1999. Approximate scale 1:562,000.

Table 4. Seasonal home ranges and core areas for radio-tagged fishers during 1996-2000, Williston Fisher Inventory Project.

Fisher ID	Sex	n[a]	Years	Home range (km^2) 95% MCP	95% UD[b]	Core area[c] (km^2)
Winter						
F01	M	21	97, 98	97.0		
F02	F	51	97, 98, 99	85.6	52.0	10.7
F04	F	25	97, 98	46.3		
F07	F	15	97, 99	25.3[d]		
F09	F	26	97, 98, 99	40.8		
F17	F	18	98, 99	24.6[d]		
F20	M	19	98,99	123.1[d]		
Non-winter						
F01	M	39	97, 98	153.6	228.7	52.1
F02[e]	F	50	97, 98, 99	29.1	17.8	3.1
F03[e]	F	33	97	19.1	5.9	1.4
F04[e]	F	28	97, 98, 99	15.8		
F05[f]	F	34	97	40.6	87.5	20.4
F07[e]	F	36	97	26.7	19.6	4.2
F09[e]	F	45	97, 98, 99	58.1	140.8	38.1
F17	F	17	98, 99	16.3d		
F18	F	17	99	15.6[d]		

a includes all capture, mortality, aerial telemetry, and ground telemetry locations, except for multiple observations at the same location
b Utilisation distribution estimated from fixed kernel method
c 50% utilisation distribution
d 100% MCP
e female rearing kits
f female without kits

ranges (x = 14.4 km^2, SE = 4.3, n = 3) than the reproducing female whose non-winter home range did not include these ecosystems (F09; 140.8 km^2). The size of non-winter home ranges was not significantly different from the annual home ranges (paired-sample t-test, t = 0.52, df = 5, P = 0.634).

We radio-tagged 5 juvenile fishers between November 1996 and January 2000: F06, F10, FH, F13, and F14. We collected sufficient information on F06 and F10 to assess their dispersal patterns. We were unable to monitor the movements of 3 of the juveniles because of mortality (FH, F14) or transmitter malfunction (F13).

We followed F10 for 2 months in late 1997. F10 was exhibiting signs of site fidelity before she died, which suggests that she had located a suitable area in which to establish a home range. During the 2 months that she was transient, F10 covered over 1,200 km^2, travelled at least 132 km, and died of starvation 77 km from where she was captured.

During 1998, we followed F06 for 7 months (17 March - 16 October), during which he appeared to establish a home range. We collected 2 locations for him around his trap location before he moved 26 km to the south-east during the first week of April, where we consistently located him in a 45.6 km^2 area until we lost radio contact with him. The centre of his new area was 20.0 km from where he was caught. F06 had covered 170 km^2 between March and mid-October.

4.5 Habitat Use

We assigned 547 locations of radio-tagged fishers collected between 18 November 1996 and 31 January 2000 to one of six precision categories (Table 5). We collected 63 element-scale, 113 patch-scale, 311 stand-scale, and 547 landscape-scale locations. However, not all of the stand- and landscape-scale locations were suitable for use in habitat analyses because we were unable to generate home range estimates (required for landscape analysis) for 12 fishers (see Table 3).

4.5.1 *Landscape Scale*

We determined the biogeoclimatic variant classification for 547 locations of 21 radio-tagged fishers from 18 November 1996 to 31 January 2000. We located fishers primarily in the SBSmk2 (403 of 547 locations, 73.7%), but also in the SBSwk2 (21.3%), SBSmkl (3.1%), Boreal White and Black Spruce dry-cool 1 variant (BWBSdkl, 1.5%), and Engelmann Spruce - Subalpine Fir moist-very cold 3 variant (ESSFmv3; 0.4%).

Table 5. Precision of 547 locations of radio-tagged fishers collected during 1996 - 2000, Williston Fisher Inventory Project.

Estimated precision	Error area	Scale analysis[a]	1996-1997	1997-1998	1998-1999	1999-2000	Total
±<1 m	none	E, P, *S*, L	1	11	33	18	63
± 1-30 m	< 0.3 ha	P,S,L	3	29	7	11	50
± 30-50 m	0.3 - 0.8 ha	S,L	0	106	6	13	125
± 50-100 m	0.8 - 3.0 ha	S,L	0	25	21	27	73
± 100-250 m	3.0 -19.6 ha	L	26	81	9	8	124
± >250 m	> 19.6 ha	L	12	40	38	22	112

[a] E = element, P = patch, *S* = stand, L = landscape (home range)

4.5.2 *Stand Scale*

Although we did not complete any aerial telemetry flights between March 1999 and January 2000, we recorded the dominant tree species of 249 stands used by radio-tagged fishers from 25 November 1996 to 15 December 1998 (Fig. 3). We observed fishers primarily using stands that were dominated by hybrid spruce (84 of 249 locations; 33.7%) and areas regenerating from clearcuts or burns, usually composed of a mix of planted species and naturally regenerating species (5 - 30 years old; 30.1%). Fishers also used stands comprised mostly of lodgepole pine (17.3%), black cottonwood (9.3%), trembling aspen (3.6%), open or otherwise recently disturbed habitats (3.2%), other deciduous (1.6%), black spruce (0.8%), and subalpine fir (0.4%).

4.5.3 *Element Scale*

We located 11 radio-tagged fishers at 63 element-scale locations between 18 November 1996 and 31 January 2000. The majority of these locations were of resting fishers (35 of 63 locations), but we also identified 13 sets of tracks of radio-tagged animals, 13 natal or maternal dens, and 2 locations for which the activity of the fisher was unknown (slipped radiocollars). We located fishers resting on rust brooms or branches of 18 hybrid spruce trees, in cavities of 4 black cottonwood and 3 trembling aspen trees, under a large piece of CWD on 6 occasions, and in burrows or rock crevices 4 times (Table 6).

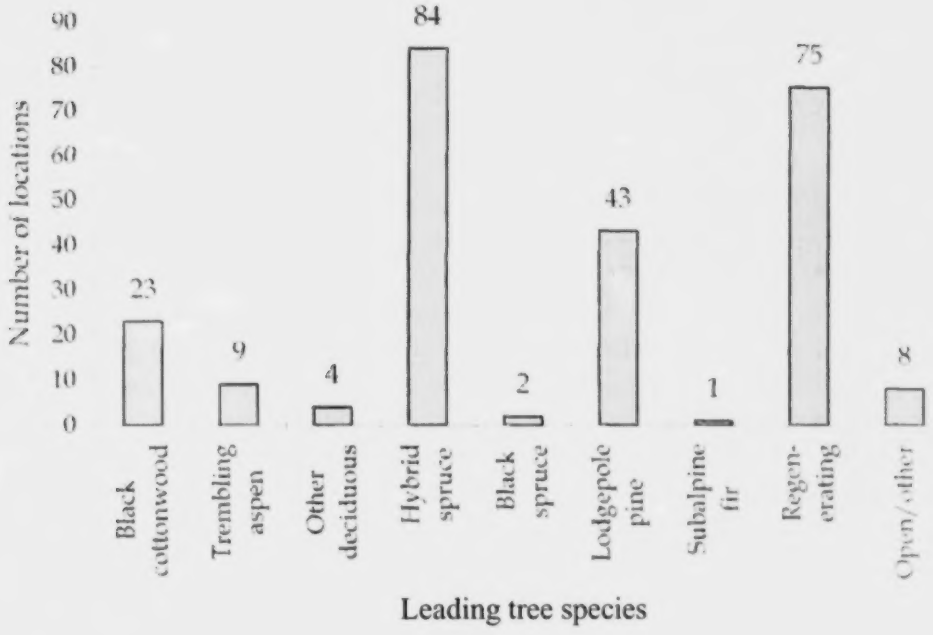

Figure 3. Leading tree species of stands used by radio-tagged fishers, as recorded on aerial telemetry flights during 1996-98, Williston Fisher Inventory Project. *N* = 249 locations.

We recorded the ambient temperature near 30 of the 35 rest sites while they were occupied by fishers. The type of rest site selected by fishers varied with ambient temperature ($F_{3,26} = 3.80$, $P = 0.022$). Temperatures were colder when fishers used CWD sites ($\bar{x} = -11.2$ C, $n = 6$) than when they used branch ($\bar{x} = 2.1$ C, $n = 15$) or cavity sites ($\bar{x} = 0.9$ C, $n = 6$). There were no significant differences between the temperatures at which fishers used CWD sites and ground sites ($\bar{x} = -7.5$ C, n = 3) or between ground sites and branch or cavity sites.

We also located female fishers in 8 natal and 5 maternal dens during the 3 rearing seasons between 1997 and 1999. All of the females reared kits in cavities in large diameter, declining black cottonwood or balsam poplar *(Populus balsamifera* ssp. *balsamifera)* trees (Table 7). The mean dbh of black cottonwood trees ($\bar{x} = 112.1$ cm, SE = 7.1, $n = 11$) was larger than the one balsam poplar tree (63.5 cm). All of the den entrances were between 3 and 26 m above ground level ($\bar{x} = 15.4$ m, SE = 2.0, $n = 12$).

Table 6. Element-scale locations of radio-tagged fishers collected from 18 November 1996 to 31 January 2000, Williston Fisher Inventory Project.

Fisher		Whelping		Resting					
ID	Active	Natal	Maternal	Branch	Cavity	CWD	Ground	Unknown	Total
F01		–	–	1					1
F02		1	2	3	2	2			10
F03		1	1	1					3
F04	1	2	1	3		1	2	2	12
F05				1					1
F07		1	1				1		3
F09		2		1	1				4
F15					1	1			2
F16		1							1
F17	5			3	1	2			12
F18	2			2	2				6
F20	5	–	–	3			1		9
Total	13	8	5	18	7	6	4	2	63

Table 7. Characteristics of natal and maternal dens used by radio-tagged female fishers during 1997, 1998, and 1999 Williston Fisher Inventory Project. F02 used 2 cavities in her 1998 natal den tree as well as 2 different maternal den trees during the same year.

ID	Date first confirmed	Use - year	Tree spp[a]	DBH (cm)	DDH[b] (cm)	Den height (m)	Den entrance height (cm)	Den entrance width (cm)	Den entrance Aspect (°)	Den chamber height (cm)	Den chamber width (cm)	Den chamber depth (cm)
Natal dens												
F03	16/04/97	natal - 97	Act	105								
F04	04/04/97	natal - 97	Act	87	89	6	5	4	183	90		
F07	02/04/97	natal - 97	Act	105	67	10	7	8	110	203	38	38
F09	03/04/97	natal - 97	Act	113	70	16	10	13	135	190	20	20
F16	19/04/97	natal - 97	Acb	63	56	10	100	6	195	210	32	32
F02	31/03/98	natal - 98[c] & 99	Act	131	66	19	9	8	250	290	10	10
		natal - 98[d]			66	16	10	20	25	40	50	50
F04	06/04/98	natal - 98 & 99	Act	88	50	21	9	5	2	440	16	20
F09	01/04/98	natal - 98	Act	95	56	26	8	8	337	280	35	35
Maternal dens												
F03	23/05/97	maternal - 97	Act	137	79	20	20	19	140	10	40	20
F07	29/05/97	maternal - 97	Act	84	54	20	13	10	210	335	10	30
F02	15/05/98	maternal - 98(1)	Act	135	130	3	74	5	205	800	70	10
F02	07/06/98	maternal - 98(2)	Act	152	84	18	7	9	167	90	9	9
F04	28/05/99	maternal - 99	Act	80								

a Acb = balsam poplar, Act = black cottonwood
b diameter at den entrance
c natal cavity 1
d natal cavity 2

The dbh of the natal dens ($\bar{x}$ = 98.4 cm, SE = 7.2, n = 8) was not significantly different than that of the maternal dens ($\bar{x}$ = 117.6 cm, SE = 14.8, n = 5; paired-sample t-test, t = 0.34, df = 2, P = 0.753). All of the entrances to the cavities were through holes resulting from large branches breaking away from the bole or cracks into the heartwood.

We climbed den trees and measured the characteristics of the dens (Table 7). The mean diameter of the bole at the den entrance was 72.2 cm (SE = 6.3, n = 12), while the mean diameter of the bole at the cavity bottom was 68.1 cm (SE = 4.4, n = 7). The mean aspect of the entrances to the dens was 174° and was significantly different from random (Rayleigh's z = 198.07, n = 12, $P < 0.001$). The mean dimensions of the den entrances were 22 cm in height (SE = 9, n = 12) and 10 cm in width (SE = 2, n = 12).

The chambers used by the females to house the kits were fairly similar among natal and maternal dens. All of the cavities were cylindrical with relatively flat bottoms. The mean dimensions of the den chambers were 30 cm in width (SE = 6, n = 11), 25 cm in depth (SE = 4, n = 11), and 248 cm in height (SE = 62, n = 12). The width and depth of the chambers were not necessarily consistent from the top of the chamber to the bottom; irregularities in the decay of the heartwood often changed the dimensions of the chamber cavity. The bottom of the chamber may not have always been used as the bed; at 2 of the dens, females appeared to have used platforms within the cavity. We did not observe any hair or faeces at the bottom of these chambers, although the walls of the chambers were extensively scratched.

4.6 Reproduction

We detected only 2 of the 5 female fishers exhibiting whelping behaviour during 1999. We observed both F02 and F04 re-using their natal dens from 1998 for rearing kits during spring 1999. Although we were unable to monitor F09 sufficiently to determine her reproductive status due to poor performance of her radiotransmitter, we located her using her natal den tree from 1997 during early June 1999. The re-use of natal dens from previous years by F02 and F04 suggest that F09 may have been re-using the tree for rearing kits. We did not detect F17 or F18 exhibiting any signs of whelping kits during 1999, despite both fishers being developmentally capable (i.e., 2 years of age).

We identified the parturition date of only one of the 2 females that had kits during 1999; F04 gave birth to kits on 3 April. F02 gave birth to her kits sometime between 10 and 25 April (assumed 11 April), but we were unable to confirm this because of logistical constraints. The mean parturition date of females during the 3 whelping seasons of 1997-99

was 6 April (median = 3 April, SE = 2.1 days, range: 30 March - 19 April, n = 10).

We collected data on den attentiveness for F04 at her natal den from 8 April to 1 May 1999, for a total of 588 hours of continuous monitoring (Fig. 4). F04 spent between 4 and 16.25 hours in the den each day ($\bar{x}$ = 9.89 hours, SE = 0.66, n = 24). The amount of time she spent in the den each day was not correlated with the days since parturition (linear regression, F = 0.62, P = 0.441). F04 discontinued using her natal den on 1 May, after which she began using a maternal den about 70 m away.

We experienced technical difficulties with the monitoring station that we set up at F02's eventual natal site. In late April 1999, we identified F02 using the natal den she used in 1998 and established a monitoring station at that site. Unfortunately, the data-logging receiver malfunctioned between 2 and 8 May and the data that were collected between 8 May and 4 June became corrupted during data transfer from the unit. Consequently, we did not collect any den attentiveness data for F02 during 1999.

4.7 Habitat Sampling

We completed 84 fisher patch plots, 81 patch comparison plots, and 4 stand description plots from June to September 1999. We completed plots at 74% of the patch-scale locations (39 patch- and 45 element-scale locations; Table 8).

We identified the site series and structural stage at 81 of the 84 stands in which we did FPP and PCP plots for fisher locations. The sets of plots that we completed were not a random representation of all of the plots that needed to be done; we completed habitat assessments at clusters of patch-scale locations within the study area to maximize efficiency. Thus, the points for which we completed plots may not be a representative sample of the habitats used by fishers. Conclusions regarding habitat selectivity based upon information collected during habitat sampling should only be made after all of the patch-scale locations have been sampled.

We performed sets of plots (FPP and PCP for a fisher location) in 14 BEC ecosystems throughout the study area (Fig. 5). We completed 5 sets of plots in the SBSmkl, 58 in the SBSmk2, and 18 in the SBSwk2. The majority of the plots that we completed were in the SBSmk2/06 and SBSmk2/05 site series (14 and 12 respectively, Fig. 5). We completed 34 sets of plots in stands with mature forest structural stage, 25 in tall shrub, 12 in young forest, 5 in low shrub or shrub/herb, 4 in

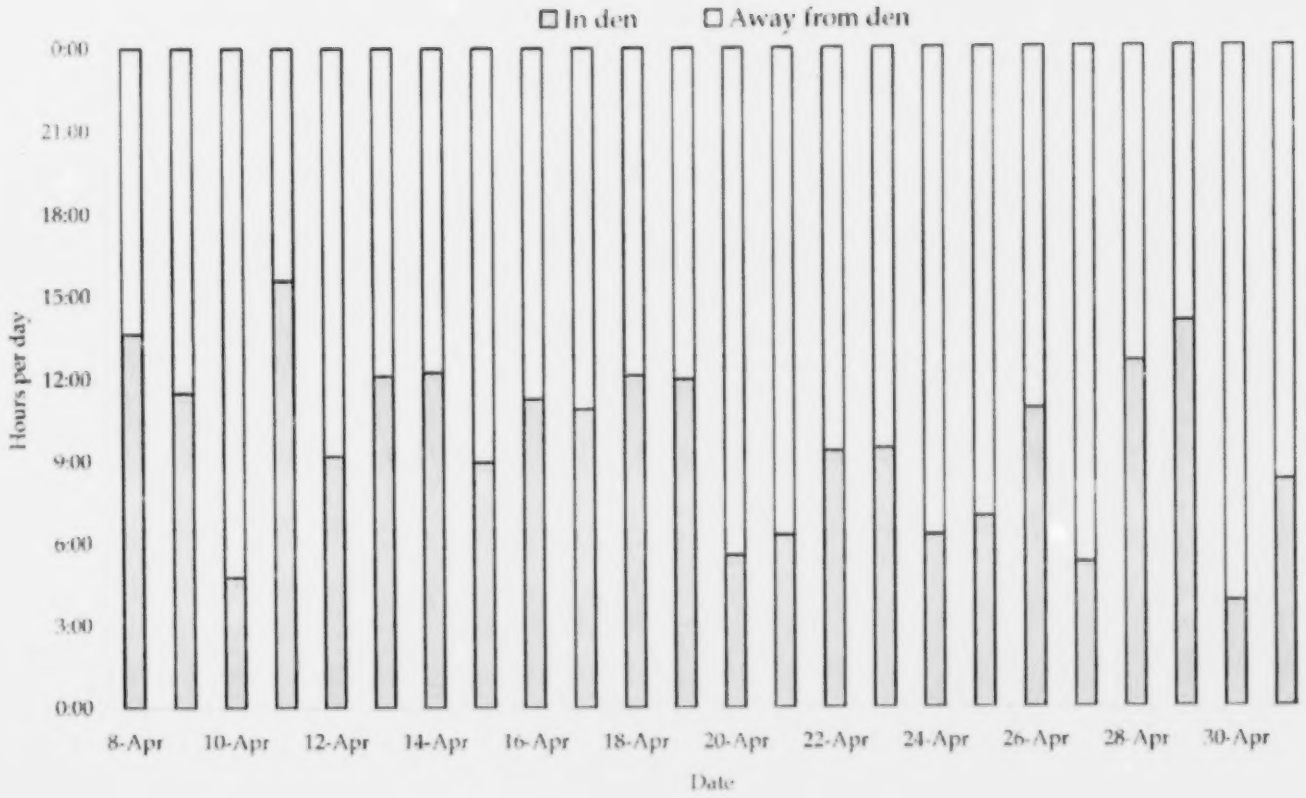

Figure 4. F04 natal den attentiveness during 1999, Williston Fisher Inventory Project. Bars represent the total hours per day away from or in natal den (not timing). F04 used her natal den from 3 April to 1 May.

Table 8. Spatial scales of the locations for which habitat plots were completed and remain for each fisher as of 31 January 2000, Williston Fisher Inventory Project. Fisher patch plots were completed at the actual fisher location, while patch comparison plots were completed at a randomly selected point elsewhere within the same stand.

	Fisher patch plots				Patch comparison plots		
Fisher	Completed		Remaining		Completed	Remaining	
ID	Patch	Element	Patch	Element			Total
F01	3		1	1	4	1	5
F02	8	11	1		17	3	20
F03			1	3		4	4
F04	6	7	3	4	13	7	20
F05	3	1	1		4	1	5
F06	1				1		1
F07	8	3	1		10	2	12
F09	9	4			13		13
F15		2			2		2
F16				1		1	1
F17	1	7	2	4	8	6	14
F18		3		3	3	3	6
F20		7		3	6	4	10
Total	39	45	10	19	81	32	113

old forest, and 1 in pole-sapling. Of the 75 stands for which stand composition modifiers (i.e., which type of tree comprise >75% of total cover) could be estimated, 43 sets of plots were in coniferous stands, 24 were in mixed coniferous-deciduous stands, and 8 were in deciduous (black cottonwood) stands. We also completed stand description plots at 4 locations throughout the study area. The stands in which we completed plots are listed in Appendix 1.

We grouped each site series into 7 different ecosystem types based upon similarity of site factors, vegetation community, and structural complexity (Table 9). Using this classification system, we completed plots in all 7 ecosystem types (spruce-moist, spruce-zonal, spruce-wet, spruce-dry, black spruce, pine-cladina, and bog; Table 10). The stand types that we will use for habitat analysis were based upon possible combinations of these ecosystem types with structural stages, stand composition modifiers, and structural stage modifiers.

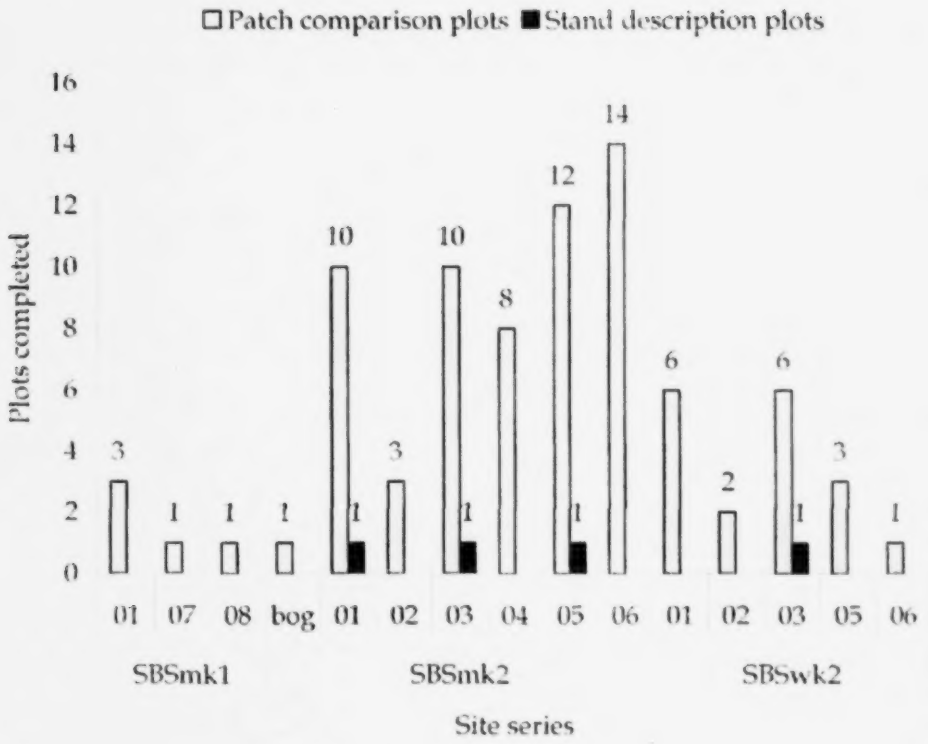

Figure 5. Biogeoclimatic ecosystem classification of random plots completed during summer 1999, Williston Fisher Inventory Project. *N* = 81 patch comparison plots, 4 stand description plots.

Table 9. Proposed grouping of BEC site series into ecosystem types for habitat analysis, Williston Fisher Inventory Project.

Ecosystem type	Site associations	TEM labels[a]	Site series		
			SBSmkl	SBSmk2	SBSwk2
Spruce - Zonal	Sxw - Black huckleberry - Highbush-cranberry	SB, SC	01	01	03
Pine - Cladina	Pl - Feathermoss - Cladina Pl - Huckleberry - Cladina Pl - Cladina - Step moss	LC, LH, LM	03, 02[b]	02	02[b]
Spruce - Dry	Sxw - Huckleberry - Soopolallie SxwFd - Knight's plume SxwFd - Toad-flax	SS, DK,ST	04[b], 05	03	
Black Spruce	Sb - Huckleberry - Spirea SbPl - Feathermoss	BH, BF	06	04	04
Spruce - Moist	Sxw - Oak fern Sxw - Devil's club	SO, SD	07, 08	05	01, 05
Spruce - Wet	Sxw - Horsetail	SH	09	06	06[b]
Bog	Bog ecosystems Sb - Scrub birch - Sedge	BB, WS	10	-	-

[a] site series symbols used in terrestrial ecosystem mapping product
[b] uncommon in study area

Table 10. Ecosystem types and structural stages of plots completed during summer 1999, Williston Fisher Inventory Project. Bracketted numbers represent stand description plots. *N* = 81 patch comparison, 4 stand description plots.

	Structural stage					
Ecosystem type	Herb-shrub	Pole-sapling	Young forest	Mature forest	Old forest	Total
Spruce - Zonal	12(1)		2	5(1)		19(2)
Pine - Cladina			4	1		5
Spruce - Dry	6			4(1)		10(1)
Black Spruce	2	1	2	3		8
Spruce - Moist	7			13(1)	3	23(1)
Spruce - Wet	3		3	8	1	15
Bog			1			1
Total	30(1)	1	12	34(3)	4	81(4)

5.0 DISCUSSION

5.1 Capture, Immobilisation, and Tagging

The relatively low capture rate that we observed during November 1999 may have been the result of high prey densities combined with very little snow cover. Snowshoe hares were entering a peak year in their cycle and were extremely common in the study area. Thus, the incentive for fishers to enter the traps (hunger) was probably somewhat diminished. The minimal amount of snow during the live-trapping session may not have restricted the movement of the fishers as much as with deep snow, which would have concentrated their activities within certain areas of their home ranges.

The intraperitoneal (IP) transmitters that we used in the fishers seemed to function well and we noticed no negative effects on the fishers from the surgery or the transmitters. Although IP transmitters require sterile surgical placement into the abdominal cavity under deep anaesthesia, this technique overcomes several disadvantages that are associated with conventional collar-type radiotransmitters. In our experience, the most important disadvantage of radiocollars is that subtle variations in the body weight or condition of the fisher may lead to significant alterations in the fit or premature loss of the collar. There were no indications that any of the 7 fishers that underwent implant surgery had complications resulting from the IP transmitters or the surgeries. We replaced IP transmitters in 2 previously implanted fishers; in neither case did we observe any adhesions nor other evidence of internal damage caused by the surgery or transmitter. The range over which we detected signals from IP transmitters was comparable to that of standard radiocollar transmitters. With the use of appropriate methods and materials, IP transmitters provide a realistic alternative to collars in radiotelemetry studies of fishers. Healthy fishers appear to be robust surgical candidates and do not appear to be negatively affected by IP transmitters.

5.2 Mortalities

Since 1996, we have confirmed that at least 9 of 21 study animals (43%) have died. Sources of mortality were fur trapping (3 fishers), starvation (2), predation or interspecific attack (2), attack by conspecifics (1), and live-trapping (1). Another 2 study animals may have died, but we were unable to validate the cause of their respective mortality signals (F05, F06). Also, at least 5 non-study animals have been harvested by fur trappers from within the study area during that time. Given that the density of fishers within the southern portion of the study area does not

likely exceed 1 fisher/150 km^2 (about 8 resident fishers in 1,200 km^2), the apparently high mortality rate of fishers that we have observed may have a strong effect on the population. Continued effort should be directed toward assessing survivorship rates from radiotelemetry data to help determine the vulnerability of the fisher population.

5.3 Home Range and Movements

The annual home ranges of the fishers in this study appear to be larger than those reported elsewhere in British Columbia. The mean annual home range size of female fishers in south-central British Columbia was reported to be 26.4 km^2 (Weir 1995), while the size of the home ranges of females in our study was 89% larger (49.8 km^2). The one male fisher that we monitored had a home range (314.8 km^2) that was approximately 130% larger than the largest male home range elsewhere in British Columbia (summer home range, R.D. Weir, unpublished data). The reasons for the differences in size of home ranges between our study and that of Weir (1995) are unclear. The resources that fishers require may be distributed more sparsely in our study area, so fishers may need to cover larger areas to sequester enough resources to survive.

Seasonal home ranges of fishers in this study were generally larger during the winter season than during the non-winter season. This result is contrary to that reported by Weir (1995), who observed that home ranges were largest during the summer. This difference may be the result of Weir (1995) using translocated animals that were establishing home ranges during summer and unfamiliar with their surroundings. All of the fishers in the current study were resident adults that were presumably familiar with the areas in their home range. Thus, they may have been able to locate resources more effectively because of this familiarity. Additionally, female fishers in this study may have had smaller home ranges during the non-winter season because they were tending to kits, whereas none of the translocated fishers in Weir's (1995) study had offspring during their first summer following release. We need to collect sufficient locations from more fishers and calculate additional seasonal home ranges to examine the relationship between season and home range size more closely.

The preliminary result of differences in home range sizes among females with kits may be the result of habitat quality affecting home range size. Thompson and Colgan (1987) reported that home ranges of martens that included uncut forest were smaller than those that included logged forest; the difference in home range size was attributed to the differences in resources available between these habitats. The

differences that we observed between the sizes of home ranges that included extensive floodplain ecosystems and those without may also be the result of the same relationship. Large, declining black cottonwoods for whelping and structurally complex habitats for foraging are likely found in the highest densities in floodplain ecosystems. Correspondingly, those home ranges that were comprised primarily of floodplain habitats were smaller than the one home range without these habitats. To be able to examine this trend more closely, we need to tag and monitor additional female fishers whose home ranges do not include extensive floodplain ecosystems.

The home ranges of the fishers in this study appear to follow the intrasexually exclusive spacing pattern that is common among members of the genus *Martes* (see Powell 1994, Weir 1995). We observed little overlap of annual home ranges among female fishers, but extensive overlap between the home ranges of F01 (male) and F09 (female). The overlap of female home ranges that we observed on the Manson River occurred between F04 and F07 and between F07 and F02. The respective locations that contributed to this spatial overlap occurred at very different times and may be the result of temporal avoidance (Weir 1995).

We noted an apparent rearrangement of home ranges following the death of F07 in January 1999. We observed that F17 assumed the home range of F07. In addition, the overlap that we observed among F17, F04, and F02 may have been the result of rearrangement of the spatial organization of these three females. This result is similar to those of Arthur *et al.* (1989), who noted that fishers shifted or enlarged their ranges to include areas left vacant when others of the same sex were removed. The apparent overlap of the home ranges among F04, F17, and F02 may be derived from locations of F17 obtained prior to her assuming F07's home range. Future home range analysis should exclude the locations before and immediately following F07's death to determine if the overlap persisted following the assumption of the area by F17.

The observation that several female fishers had not established home ranges by the end of their first year is unusual. F17 overtook the home range of F07 when she was 2 years of age, which is slightly older than the age at which most fishers have been reported to establish home ranges (juvenile; Arthur *et al.* 1993, Powell 1993). We observed one other transient fisher during the course of this study that did not appear to have established home ranges while it was a juvenile; F15 died at 1.8 years, having never apparently established a home range. This long duration of transiency may be due to a limited amount of

suitable, unoccupied habitat in which dispersing fishers can establish home ranges.

We were unable to document many examples of juvenile dispersal because of low survivorship of juveniles and difficulties capturing this age class. We were only able to follow 2 of 5 juvenile fishers for more than a month: F10 during November and December 1997 and F06 from March to October 1998. The distance and area over which F10 travelled while she was transient were large compared to F06 and other transient fishers reported elsewhere in the literature. Weir (1995) reported that 2 translocated fishers in south-central British Columbia ranged over at least 900 km^2 while transient. As noted by Weir (1995), large rivers and elevational changes were not barriers to movement; during F10's transient period, she crossed over both the Mesilinka and Ingenika Rivers and was located at elevations to 1,200 m. The farthest that female fishers in Maine dispersed was 22.6 km from their natal territories (Arthur *et al.* 1993), which was substantially less than the net dispersal distance exhibited by F10 (77 km). More work should be directed to examining the factors affecting dispersal patterns of juvenile fishers.

5.5 Habitat Use

5.5.1 *Landscape Scale*

Fishers in our study area used the SBSmk2 biogeoclimatic variant more frequently than other variants. This result was not unexpected because we trapped primarily in the SBSmk2 and the ranges of 7 of the 21 fishers that we monitored were comprised almost entirely of this variant. Conclusions regarding landscape selection by fishers should only be drawn once we have completed use versus availability analyses.

5.5.2 *Stand Scale*

As recorded during aerial telemetry flights, the frequent use of hybrid spruce stands as well as regenerating clearcuts or burns is not unexpected. Both of these stand types comprise substantial proportions of our study area and use of these stand types may not constitute any preference by fishers for these stand types. Conclusions regarding habitat selectivity should only be drawn after the appropriate use versus availability analyses have been performed.

The data from which we will assess stand-scale habitat selectivity has not been fully collected to date. We have collected information on the stands used by fishers at 81 of 311 locations of radio-tagged fishers, but

this information was not a representative sample of all fisher locations. To be able to perform stand-scale analyses, we require a completed ecosystem map to estimate the availabilities of stands within the home range of each fisher as well as to determine the stands used by each fisher within its home range.

5.5.3 *Element Scale*

5.5.3.1 Natal and Maternal Dens

We have identified 8 natal and 5 maternal dens, all of which were located in large diameter ($\bar{x}$ = 105.7 cm), declining black cottonwood or balsam poplar trees. Unlike eastern studies, where fishers whelp in smaller diameter trees (Maine: $\bar{x}$ = 45 cm, Paragi 1990; New England: $\bar{x}$ = 66 cm, Powell *et al.* 1997; Wisconsin: $\bar{x}$ = 60.9 cm, Gilbert *et al.* 1997), fishers in our study seemed to use atypically large trees in which to whelp. These types of trees appear to have distinctive characteristics that make them suitable for denning and make them rare elements within the landscape (Weir 1995).

All of the dens consisted of cavities in the inner heartwood, which were accessed via holes through the hard outer sapwood. Black cottonwood trees are prone to decay of the heartwood at an early age (Maini 1968), but appear to form cavities sufficient for rearing by fishers only when the bole at the cavity height is greater than 54 cm diameter. For the cavity to be used by fishers, it also appears that the cavity entrance may need to be greater than 5 m above ground. Thus, for fishers to use black cottonwood trees for natal or maternal dens, it appears that the trees need to have heart rot and a bole diameter greater than 54 cm at 5 m above ground. Elements with all of these traits may be rare across the landscape of the SBS biogeoclimatic zone and may be an important component in the selection of home ranges by female fishers (Weir 1995). Future work needs to determine the frequency with which these features occur and the effects of the distribution of these elements on female fishers.

The aspects of the den openings were significantly different from random with the mean aspect facing south, which likely conferred some thermal advantages to the female and her kits. Although Powell *et al.* (1997) did not find that female fishers in central New England selected den openings with any specific aspect, Paragi (1990) found that the mean aspect of natal dens in Maine was also to the south. The southern aspect of the entrance, in addition to the height of the cavity, likely maximises the amount of solar radiation that enters the den cavity. This likely confers some thermal advantages to the female and kits (Leonard

1980). Thus, our data support the hypothesis that fishers select dens that offer a favourable microclimate (i.e., high above ground, facing the sun). However, the aspect of the entrance may be selected to avoid cold northerly winds or may be a function of the availability of access points to cavities. Possible future effort may be directed towards examining the distribution the aspects of branch-hole entrances, determining if the aspect of maternal dens (i.e., those used after the natal den) favours the south, and examining which environmental factors affect selection of entrance aspect.

5.5.3.2 Resting Sites

The selection of resting sites by fishers appears to be temperature dependent. As hypothesised by other researchers, tree cavities or burrows provide microclimates for small endotherms that are quantitatively and qualitatively different from other sites in their environment (Taylor 1993). Fishers used tree branch and tree cavity resting sites when the ambient temperature was warmer, which is consistent with Taylor's (1993) hypothesis that snags and branches offer an adequate thermal environment under most winter conditions.

Other studies of fisher ecology have noted that the selection of rest sites may be affected by temperature. Arthur (1987) reported that fishers' use of particular habitat attributes for resting was seasonal; during winter, fishers primarily rested in ground sites, but used tree sites more frequently during spring and fall. Taylor (1993) determined that subnivean cavities offered the warmest micro-environment during severe winter weather, which would explain why we observed fishers using these sites when the ambient temperature was cold (i.e., below -15 C.

Large pieces of CWD may be important habitat structures for fishers during long periods of extremely cold temperatures because these structures likely provide a more favourable thermal micro-environment than that found at other types of rest sites. Our results have implications for habitat management and conservation of old forest structures for fishers in regions with cold climates.

5.6 Reproduction

The patterns of whelping that we observed were broadly compatible with results reported elsewhere. The mean whelping date of the 6 females with kits was 6 April, which was not substantially different from that reported by Weir (1995) in south-central British Columbia (10 April). However, in eastern portions of their range, fishers whelp much earlier (4 March - 24 March, Powell *et al.* 1997). This difference in

whelping dates is likely due to climatic differences and seasonal food availability between the two regions.

Female fishers in this study changed dens as the rearing season progressed. Although we located only 5 maternal (i.e., post-natal) dens, we observed that each of these females abandoned their natal den after 5 to 8 weeks of use. This period of use of the natal den was longer than that reported by Powell *et al.* (1997) in New England and Paragi (1990) in Maine, who each noted that female fishers used 1-5 dens over a 6-8 week period while rearing their kits. Elsewhere in British Columbia, 4 female fishers changed dens after 2-3 weeks of occupancy (R.D. Weir, unpublished data).

We may have been unable to locate subsequent dens for 4 of the 6 females because of the decreased time that females spent at later dens. However, females with home ranges that did not include extensive riparian habitats tended not to move to maternal dens (F09, F04). The availability of suitable denning opportunities perhaps affects the likelihood of a female moving her kits to maternal dens. To examine this relationship more closely, we should intensively monitor females with kits for the entire rearing season to locate all maternal dens that are used following parturition.

5.6.1 *Re-use of Natal Dens*

We recorded re-use of natal dens by at least two female fishers during 1999. This phenomenon has not been widely reported in the literature, although a female fisher in south-central British Columbia used the same black cottonwood tree for rearing kits in successive years (Weir 1995).

The reasons for the re-use of the same tree for whelping are unclear. Perhaps trees that are suitable for whelping are rare across the landscape and females have a limited selection of appropriate sites for rearing kits. Conversely, females that have successfully reared kits in previous years in a particular element may simply select that element in future years because it is known to possess the appropriate combination of features that are needed to raise kits. Future effort should be directed towards continuing to assess re-use of natal dens and determining if the availability of suitable denning sites is limited across the landscape.

5.6.2 *Den Attentiveness*

The den attentiveness pattern that we observed during 1999 seemed to fit broadly with attentiveness patterns exhibited by other mustelids (Henry *et al.* 1997). Although we did not detect a significant decline in

the amount of time that F04 spent away from the den as the kits grew older, this may be because she was still nursing kits during the 4 weeks immediately following parturition. Henry *et al.* (1997) noted a significant difference between the duration of time that female martens spent at their natal dens between pre-weaning (i.e., nursing) and post-weaning (i.e., solid food). Perhaps we did not notice any significant decrease in the time away from the den because we did not monitor the maternal den (when the kits would likely have been weaned).

We may have documented the timing of breeding of F04 from the den monitoring. Fishers are in estrus for 3-6 days beginning 3-9 days following parturition (Powell 1993). Some of the substantial absence by F04 from her natal den during the 2 weeks following whelping may have been the result of breeding attempts. Based upon the assumed parturition date of 3 April, the extended absences on 10 and 20 April may have been to find and mate with reproductive males in the area.

5.7 Habitat Sampling

We completed a little over three-quarters of the fisher patch and patch comparison plots needed as of 31 January 2000. We still need to complete 29 fisher patch plots and 32 patch comparison plots for 10 patch- and 19 element-scale locations. We will also need to complete plots at any additional patch- or element-scale locations that are collected before 1 June 2000.

5.7.1 Future Habitat Sampling

Because we are already familiar with the habitat sampling techniques, I expect that we will be able to average 4.5 plots per day during summer 2000. Assuming that we will collect an additional 25 patch- or element-scale locations of radio-tagged fishers during 2000, we should be able to finish all of the patch-scale habitat assessments (54 fisher patch and 57 patch comparison plots) in roughly 25 days of fieldwork.

The number of plots that we will need to complete to adequately describe each stand type will be dependent upon the heterogeneity of that stand type. For example, the young forest stage of the Pine-Cladina ecosystem type is relatively monotypic, with widely spaced trees, little shrub cover, and virtually no CWD. Thus, we will be able to obtain a reasonable level of precision with relatively few plots (e.g., 3). However, the herb-shrub stage of the Spruce-Moist ecosystem can have widely variable amounts of CWD and shrub cover, depending on the type of disturbance that caused the ecosystem to revert to an early structural stage (e.g., fire versus logging). In this instance, we may need to obtain 8 or 9 samples to have a reasonable level of precision. The

level of precision that will be required to discontinue sampling each stand type will be determined with a sequential sampling approach.

The stands in which stand description plots remain to be completed during summer 2000 are affected primarily by the locations of fisher plots. The data from the randomly located patch comparison plots will be used to estimate structural variables for each stand type. Thus, the stand description plots will be performed only in stand types in which no fisher plots were performed or where the variability within a stand type at patch comparison plots was high enough that additional samples were required. Using this approach, I expect that we will need to complete 61 stand description plots during summer 2000 (Table 11). At a rate of 4.5 plots per day, we should be able to complete the stand description plots in 13 or 14 field days.

Table 11. Estimated number of stand description plots for each stand type (ecosystem type and structural stage) to be completed during summer 2000, Williston Fisher Inventory Project. Cells marked with "*" are stand types that are expected to be extremely rare or non-existent; therefore, no plots will be scheduled for these stand types. Blank cells indicate sufficient number of samples collected to date.

	Structural stage					
Ecosystem type	Herb-shrub	Pole-sapling	Young forest	Mature forest	Old forest	Total
Spruce - Zonal	1	3	3	2	4	13
Pine - Cladina	3	3	1	3	*	10
Spruce - Dry		3	4		*	7
Black Spruce	3	3	2	1	*	9
Spruce - Moist	1	*	3		2	6
Spruce - Wet	1	*	1	1	3	6
Bog	4	3	3	*	*	10
Total	13	15	17	7	9	61

6.0 CONCLUSIONS

We have reached many of the goals of the fourth year of this study. We collected additional locations on radio-tagged fishers from throughout the year. We have examined the home range size and spatial organization of fishers in the study area. We have anecdotal information regarding the assumption of home ranges when animals are removed from the population. We have examined the relationship between ambient temperature and the types of rest sites used by fishers, illustrating that cold winter resting sites may be an important

habitat component. We continued to identify natal and maternal dens of reproducing females and monitor their attentiveness patterns. Our habitat sampling program has collected much of the patch- and element-scale habitat information on the radio-tagged fishers.

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8.0 APPENDIX

Appendix 1. Number of plots completed in each stand type during summer 1999, Williston Fisher Inventory Project. $N = 81$ patch comparison plots.

BGCUnit	Site series	Structural stage	Stand composition modifier	Structural stage modifier	Total
SBSmkl	01	3b	coniferous		2
SBSmkl	01	6	coniferous	two-storied	1
SBSmkl	07	3b	mixed		1
SBSmkl	08	6	coniferous		1
SBSmk2	01	3	broadleaved	multi-storied	1
SBSmk2	01	3a			1
SBSmk2	01	3b			1
SBSmk2	01	3b	coniferous		2
SBSmk2	01	3b	mixed		3
SBSmk2	01	5	coniferous	multi-storied	1
SBSmk2	01	5	coniferous	two-storied	1
SBSmk2	02	5	coniferous	single-storied	2
SBSmk2	02	5	coniferous	two-storied	1
SBSmk2	03	3a	coniferous		1
SBSmk2	03	3b			1
SBSmk2	03	3b	mixed		4
SBSmk2	03	6	coniferous		1
SBSmk2	03	6	coniferous	two-storied	3
SBSmk2	04	3b	coniferous		1
SBSmk2	04	3b	mixed		1
SBSmk2	04	4	coniferous	single-storied	1
SBSmk2	04	5	mixed	two-storied	2
SBSmk2	04	6	coniferous	two-storied	3
SBSmk2	05	3a			1
SBSmk2	05	3b			1
SBSmk2	05	6	coniferous	multi-storied	1
SBSmk2	05	6	coniferous	two-storied	1
SBSmk2	05	6	mixed	single-storied	3
SBSmk2	05	6	mixed	two-storied	2
SBSmk2	05	7	coniferous	two-storied	3
SBSmk2	06	3a			1
SBSmk2	06	3b	mixed		2
SBSmk2	06	5	coniferous	two-storied	2
SBSmk2	06	6	broadleaved	shelterwood	1
SBSmk2	06	6	broadleaved	single-storied	1

BGC Unit	Site series	Structural stage	Stand composition modifier	Structural stage modifier	Total
SBSmk2	06	6	broadleaved	two-storied	3
SBSmk2	06	6	mixed	single-storied	2
SBSmk2	06	6	mixed	two-storied	1
SBSmk2	06	7	coniferous	two-storied	1
SBSmk2	bog	5	coniferous	single-storied	1
SBSwk2	01	3b	broadleaved		1
SBSwk2	01	3b	coniferous		2
SBSwk2	01	6	coniferous	two-storied	3
SBSwk2	02	5	coniferous	single-storied	1
SBSwk2	02	6	coniferous	single-storied	1
SBSwk2	03	3b	mixed		1
SBSwk2	03	3b	mixed	single-storied	1
SBSwk2	03	6	coniferous	multi-storied	1
SBSwk2	03	6	coniferous	single-storied	1
SBSwk2	03	6	coniferous	two-storied	2
SBSwk2	05	3b	broadleaved		1
SBSwk2	05	6	coniferous	two-storied	2
SBSwk2	06	5	mixed	irregular	1
Total					81

Appendix 2. Abstracts submitted for presentation and publication at the III Martes Symposium to be held during summer 2000.

EFFECT OF AMBIENT TEMPERATURE ON SELECTION OF REST SITES BY FISHERS

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ABSTRACT: We examined the effect of ambient temperature on the selection of rest sites by 20 radio-tagged fishers *(Martes pennanti)* in two areas of central British Columbia during 1990-1993 and 1996-2000. Fishers used 5 types of sites for resting: in tree cavities, on rust brooms or tree branches, under single pieces of large coarse woody debris (CWD), in logging slash-piles, and in burrows or rock crevices. We located free-ranging fishers at 71 rest sites during all four seasons and recorded the nearby ambient temperature while these rest sites were occupied. The type of rest site selected by fishers varied with ambient temperature *(P* = 0.022). Temperatures were colder when fishers used CWD sites than when they used branch or cavity sites. Large pieces of CWD may be important habitat structures for fishers during long periods of extremely low temperatures because these structures likely provide a more favourable thermal micro-environment than that found at other types of rest sites. Our results have implications for habitat management and conservation of old forest structures for fishers in regions with cold climates.

Key words: British Columbia, coarse woody debris, fisher, *Martes pennanti,* rest site, temperature, thermoregulation

HOME RANGES AND SPATIAL ORGANIZATION OF FISHERS IN CENTRAL BRITISH COLUMBIA

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ABSTRACT: We described the size and spatial arrangement of annual and seasonal home ranges for 14 radio-tagged resident fishers *(Martes pennanti)* in two areas of central British Columbia during 1990-1993 and 1996-2000. We estimated home range size for each fisher from the 95% isopleth of the utilization distribution generated using a fixed kernel model with smoothing selected by least-squares cross-validation. The annual home ranges of female fishers ($x = 35.2$ km^2, SE = 8.1, $n = 11$) were significantly smaller than those of males ($x = 168.8$ km^2, SE = 77.0, $n = 3$; $P = 0.011$). We did not detect a significant change in size of home ranges between seasons with and without snow *(P* - 0.537), but our sample size was small. We observed minor overlap among home ranges of fishers of the same sex, but considerable overlap among home ranges of males and females, similar to behaviour exhibited by other Mustelidae. Home ranges that we observed in central British Columbia were larger than those reported elsewhere in North America. This suggests that the distribution of resources for fishers may occur at lower gross densities in central British Columbia than in other portions of the fisher's range. Our results can be used to produce population estimates for fishers in central British Columbia and will help assess the conservation status of fishers in managed landscapes.

Key words: British Columbia, fishers, home range, *Martes pennanti,* spatial organization

USE OF INTRAPERITONEAL RADIOTRANSMITTER IMPLANTS IN FISHERS

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ABSTRACT: During 2 radiotelemetry studies on fishers *(Martes pennanti)* in British Columbia, 11 fishers (7 adults, 4 juveniles) were surgically implanted with intraperitoneal (IP) radiotransmitters. Although IP transmitters require sterile surgical placement into the abdominal cavity under deep anaesthesia, this technique overcomes several disadvantages that are associated with conventional collar-type radiotransmitters. In our experience, the most substantial disadvantage of radiocollars is that subtle variations in the body weight or condition of the fisher may lead to significant alterations in the fit or premature loss of the collar. There were no indications that any of the 11 fishers that underwent implant surgery had complications resulting from the IP transmitters or the surgeries. We replaced IP transmitters in 2 previously implanted fishers; in neither case did we observe any adhesions nor other evidence of internal damage caused by the surgery or transmitter. The range over which we detected signals from IP transmitters was comparable to that of standard radiocollar transmitters. With the use of appropriate methods and materials, IP transmitters provide a realistic alternative to collars in radiotelemetry studies of fishers. Healthy fishers appear to be robust surgical candidates and do not appear to be negatively affected by IP transmitters.

Key words: British Columbia, internal transmitters, fishers, *Martes pennanti,* radiotelemetry, surgery